

costs before the institution of price caps; hence, these large gains must have occurred under price caps.) MCI's assertions are less clearly stated, but it too apparently contends that there have been efficiency gains from price caps that are now to be sacrificed by the incumbent LECs, perhaps as much as \$4.2 billion per year.<sup>7</sup>

11. MCI and AT&T ask the Commission to establish interstate access rates on the basis of forward-looking estimates of costs proffered by participants in various state proceedings. AT&T suggests that the Commission establish new rates for each interstate access element on admittedly imperfect estimates of these forward-looking costs by "re-initializing" access rates to these estimates now and then re-re-initializing these rates whenever new data becomes available.<sup>8</sup> This would be a return to prescriptive, cost-based regulation with a vengeance. MCI also recommends the immediate re-initialization of price-cap indices using proxy-cost models to reflect "a reasonable approximation" of forward-looking costs and even goes so far as to conclude that such a process would result in rates set at economic cost despite the very large uncertainties in estimating such models.<sup>9</sup> It then concludes that lowering rates in this fashion would represent a recapture of "monopoly profits" that somehow emerged during the last seven

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<sup>7</sup>MCI Comments at 26.

<sup>8</sup>AT&T Comments at 28.

<sup>9</sup>MCI Comments at 18-19.

years of price-cap regulation of the incumbent LECs.<sup>10</sup> This is no less than a total repudiation of price caps as an incentive-based form of regulation.

12. The alternative to this return to cost-based regulation is to restructure rates according to principles of cost causation, an approach favored by most commenters in this proceeding, but then allowing rates to be driven down by the continued governance of price caps and the entry of new competitors. Since the Act now requires that the incumbent LECs offer their unbundled network elements to entrants at cost-based rates and also requires them to interconnect with new entrants into local access and exchange services, competition will begin to press access rates down toward economic cost. MCI and AT&T contend that such competition will develop slowly at best despite the rather considerable progress in negotiating interconnection agreements between entrants and the incumbent LECs in the states that has already occurred.<sup>11</sup> How rapidly competition will develop is, of course, not clear, but there is no obvious barrier to the entry of carriers such as MCI or AT&T into the provision of local services once these interconnection agreements are executed. Further entry may come from those who take advantage of agreements negotiated by others. Moreover, this competition and the threat from further entry once the entry barriers are down provide the only sure mechanism for pressing access rates towards efficient network costs. Years of cost-based regulation have surely proved that the regulatory process is not likely to produce rates that are equal to efficient economic costs.

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<sup>10</sup>MCI Comments at 19-20.

<sup>11</sup>MCI Comments at 42; AT&T Comments at 44-47.

13. A major problem with the Commission's prescriptive approach is that it is inconsistent with the extension of its very successful price-cap regime. MCI and AT&T contend that the "re-initialization" and even "re-re-initializations" of price caps to reflect estimates of forward-looking costs are administratively tractable, a contention that is debatable. More importantly, both misunderstand the important efficiency-enhancing property of price caps. Price caps are not simply a convenient accounting device for implementing cost-based regulation; they are an alternative to cost-based regulation.

14. If the Commission were to adjust the price caps for interstate access elements to estimates of costs proffered by regulatory participants, no LEC could reasonably believe that its success in reducing costs in the future would not be assailed as "monopoly pricing" by purchasers of its access services bent on obtaining a new "re-initialization" of price caps. As a result, even one change would not be an adjustment to the price-cap regime; it would simply be the reinstatement of the cost-based regulatory regime that has been thoroughly discredited.

15. It is surprising that MCI and AT&T would so casually discard price caps by recommending "prescriptive" cost-based regulation. Price caps for AT&T were apparently quite successful in limiting competitors' complaints about cross subsidies and predation while providing AT&T with incentives for productive efficiency. Despite frequent reassessments by the Commission of six years of AT&T's price caps, the Commission did not seek to re-initialize

these price caps by asking for comments on the forward-looking costs of long-distance services which surely have been below AT&T's embedded costs and tariffed rates for some time.<sup>12</sup>

16. The Commission should be reluctant to embrace any new cost-based regulatory regime that would overturn seven years of successful price-cap regulation. Seven years ago, the Commission embraced price caps as the appropriate mechanism to control the LECs' interstate rates during the transition to competition because they allow the LECs to recover their costs and induce them to pursue cost minimization. Nothing has changed to warrant a sudden lurch away from price caps. Nor should the Commission place the price-cap mechanism at risk by beginning to adjust rates towards some estimate of costs that has been revealed by LECs seeking to improve their networks and to reduce their costs.

### **Price Flexibility**

17. The Commission has asked for comments on allowing incumbent LECs certain flexibility in pricing access services when access markets become contestable as the result of interconnection agreements that specify cost-based rates for unbundled elements and interconnection. Specifically, it asked for comments on allowing geographic deaveraging of rates, volume and term discounts, contract pricing, and the deregulation of new services. AT&T

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<sup>12</sup> See the Affidavit of Robert W. Crandall and Leonard Waverman appended to Ameritech's Section 271 filing for Michigan, January 1997.

and MCI oppose such added flexibility until each access market is subject to substantial actual competition on the grounds that such flexibility might be used by incumbent LECs to frustrate competition.<sup>13</sup> In fact, such flexibility is more likely to facilitate robust competition by allowing the LECs to respond to variations in costs or changes in competitive conditions.

18. AT&T and MCI do not deny that the pricing flexibility proposed by the Commission could be efficiency enhancing. Geographic deaveraging, volume or term discounts, and contract pricing would allow the incumbent LECs to adjust some of their rates more closely to actual costs, thereby leading to more efficient pricing. AT&T and MCI raise the specter of anticompetitive pricing strategies by the LECs, including cross-subsidization, rates constructed solely for self-dealing with the LECs' subsidiaries, and aggressive responses to entry threats. In his Affidavit for MCI, Professor John Kwoka argues that price caps are no "panacea" for preventing such abuses because few price cap regimes are "pure" price caps and even pure price-cap regimes provides the regulated firm with added discretion over individual rates that can be employed to frustrate entry.<sup>14</sup>

19. AT&T and MCI fail to acknowledge that what they portray as attempts by the LECs to use pricing flexibility to deter entry into the market for interstate access is simply an appropriate competitive response by the LECs to the prospects of entry. Entrants will obviously

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<sup>13</sup>MCI Comments at 55-63 and Kwoka Affidavit. AT&T Comments at 77-83.

<sup>14</sup>Kwoka Affidavit at 3-10.

attempt to exploit opportunities provided by constraints on LEC pricing that result in certain customers paying rates that are in excess of costs. If LECs are unable to respond by adjusting their rates, say, by reducing access rates in densely populated markets or highly-competitive areas, inefficient entry may take place. The entry of competitors and the response of incumbents to such entry will allow rates to reflect costs. Indeed, such flexibility in the form of geographic deaveraging, volume and term discounts, and contract pricing will often result from market signals provided by entrants, but these responses are no less conducive to efficient pricing simply because they are triggered by entry. Xerox reduced the prices of certain copiers when IBM entered its market in the 1970s. GM and Ford moderated their price increases on luxury automobiles when Japanese firms entered the luxury-car market. One would expect LECs to respond similarly if entry signals to them that some of their rates are above cost. The result of such reductions is generally beneficial to economic welfare.

20. Pricing flexibility designed to eliminate competition is another matter. As I showed in my original affidavit in this proceeding, however, the notion that the LECs could engage in predation against such large potential entrants into local access and exchange services as MCI and AT&T defies credulity. Moreover, preemptive rate reductions designed to distract customers of interstate access services from new rivals' offerings are also unlikely given the size and sophistication of customers for such services, including the large interexchange carriers themselves.

21. Nor should the Commission prevent the LECs from responding to competition by deaveraging rates simply because this deaveraging leads to higher rates in less-dense areas. Competition necessarily will press rates towards costs whether the incumbent LECs respond through deaveraging or not. If they are not allowed to compete successfully in the denser markets by lowering those rates, they will clearly find it more difficult to cover their costs in the areas that are avoided by competitors. The eventual result is likely to be even higher rates for subscribers in these low-density areas.

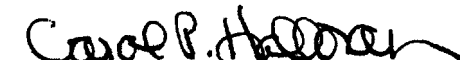
22. Finally, there is simply no likelihood that LECs would create artificial new service categories that are designed to offer discounted rates solely to their own affiliates. Such practices would be so transparent and clearly a violation of the Commission's rules as to invite a swift and severe response from the Commission. Avoiding imputation tests by such obvious and devious means would not be a rational long-term strategy for a LEC interested in gaining access to new markets through federal and state regulatory processes.

I hereby swear, under penalty of perjury, that the foregoing is true and correct to the best of my knowledge and belief.

  
Robert W. Crandall

Subscribed and sworn before me this 11<sup>th</sup> day of February, 1997.

My Commission expires 11, September 11, 1998

  
Carol P. Halloran  
Notary Public





**Before the  
FEDERAL COMMUNICATIONS COMMISSION  
Washington, D.C. 20554**

<b>In the matter of</b>	)	
	)	
<b>Price Caps Performance Review</b>	)	<b>CC Docket 94-1</b>
<b>for Local Exchange Carriers</b>	)	

**DECLARATION OF MELVYN A. FUSS**

I, Melvyn A. Fuss, declare the following:

1. Introduction

1. In my initial declaration in this proceeding, I demonstrated why use of a fixed input price differential would be inappropriate for price caps regulation of local exchange carriers. In this declaration, I reaffirm that conclusion after reviewing the comments that argue otherwise. Indeed, the most recent data included in Dr. Christensen's Reply supports my conclusion that the input price differential observed post divestiture was a temporary phenomenon which ended around 1990.
2. In Christensen's simplified TFP data set, the LEC - US input price differential was -3.0% per year for the 1985-89 period and was +0.4% for the 1990-94 period.<sup>1</sup> In other words, input prices for the LECs over the past five years grew at a slightly

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<sup>1</sup> I calculated these averages from the yearly input price differentials contained in the last column of table 3 of Christensen's Reply.

faster rate than that for the U.S. economy as a whole. As a result, if a fixed input price differential were to be included in the price caps formula, the data for the most recent period would imply a **downward** adjustment to the productivity offset.

3. In this declaration, I also respond to several recommendations offered by AT&T and the Ad Hoc Telecommunications Users Committee. I explain why their proposal to estimate productivity growth separately for interstate access services has no meaningful economic basis. They arbitrarily allocate inputs that are common to both interstate and intrastate services. In fact, there is no way legitimately to separate out the interstate portion of these inputs. As a result, their models are inherently flawed and produce meaningless results.
4. I also examine AT&T's two "new" arguments in advocating that a historically-determined input price differential should be included in the price caps formula. The first relies on an inappropriate statistical test that asks the wrong question, and is so stringent that it would find a significant input price differential (for price caps purposes) unless the input price changes for the LECs were virtually identical with national input price changes in every year examined. By focusing on whether the individual data points were identical, AT&T ignores the real issue associated with a fixed input price differential -- whether the **average** change in input prices for LECs is indistinguishable from the national average. The second argument is based on AT&T's so called "performance-based" model, which is so flawed as to undermine any conclusions based on the data it produces. Indeed, I identify a number of problems in that model which undermines its potential use as an alternative to Dr Christensen's

model. Among the problems with the model is a flawed quality adjustment procedure which results in an upward bias to the estimated input price differential.

## 2. The Estimation of a Separate TFP for Interstate Access Services

5. On behalf of AT&T, Dr. Norsworthy claims that a separate total factor productivity growth rate (TFP) can be estimated for interstate access services. From a conceptual perspective, this claim is incorrect. Separate measures of TFP for individual services can only be defined if the multiple output production function is separable into sub-functions, that is, only when it is possible to define separate production functions for each service will it be possible to calculate service-specific TFP. But it is not possible to define service-specific production functions for interstate and intrastate services as long as these services use factors of production in common.<sup>2</sup> Clearly this is the case in telecommunications, where a substantial amount of labor and especially capital are used in common by interstate and intrastate services.
6. As discussed in Appendix A, only in the case where **no** inputs are used in common by interstate and intrastate services can a LEC's total cost of production be obtained conceptually as the sum of the costs of producing interstate services and intrastate services. This means that only in this special case (not applicable to telecommunications) can total costs be **separated** in any economically meaningful way into the costs of producing interstate services and the costs of producing intrastate

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<sup>2</sup> Additional technical details of this analysis are contained in Appendix A.

services. And only in this case is it economically meaningful to measure separate TFPs for the two services.

7. In the application of his Performance-Based Model to the measurement of interstate access TFP, Norsworthy ignores this well-established principle that costs incurred jointly by two or more services cannot be separated in an economically meaningful way<sup>3</sup>. In fact he claims that "no specific allocation of costs is required" (page 27). If this were true we would have the productivity analyst's version of the free lunch. It would mean that TFP for interstate access services could be calculated without knowing anything about the inputs used to produce these services!
8. Unfortunately, the free lunch is an illusion. The statement above is immediately followed by Norsworthy's cost allocation assumption that "inputs grow at the same rates for all classes of services." (page 27). This is a particularly simplistic form of cost allocation which cannot be taken seriously as an economically meaningful allocation. Norsworthy's reliance on such a simplistic form of cost allocation is an implicit admission that no economically meaningful cost allocation procedure to determine the "costs" of interstate access services is possible.
9. Norsworthy is also incorrect in his claim that no specific allocation of costs is required by him, since he is only making an assumption about the growth rates of inputs used to produce specific services, not their levels. It is obvious that the assumption used by Norsworthy imposes a specific (i.e, equal percentage) allocation of

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<sup>3</sup> This principle is not ignored by Christensen. No attempt is made in the USTA model to obtain an interstate-specific TFP measure. Christensen's procedure is conceptually correct.

input **changes**. In any productivity study the initial (for example, 1984) levels of all inputs can be chosen arbitrarily, and are often set to unity. This must be the case otherwise the TFP estimates would be sensitive to the units of measurement of the inputs. Since the initial levels of inputs are arbitrary, allocating the changes in inputs is tantamount to allocating all the meaningful information about the inputs. It is in this sense that using the assumption of equal growth rates of inputs is equivalent to employing a specific fully-distributed cost allocation procedure.

10. A direct consequence of Norsworthy's cost allocation procedure (inputs grow at the same rate for all services) is that since the outputs for interstate access services are growing more rapidly than those for intrastate services, a higher TFP offset is assigned to these faster growing services.<sup>4</sup> This assignment is as arbitrary and lacking in economic meaning as the cost allocation procedure which determines it.

### 3. The Input Price Differential

11. Aside from repeating the conclusions of Bush and Uretsky's Appendix F regarding the input price differential, Norsworthy offers the following additional arguments:

- (i) A chi-squared test of the equality of the annual LEC and US input price changes using the Christensen data.

- (ii) His own measurement of the input price differential.

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<sup>4</sup> It is more than a direct consequence, it is an algebraic truism.

These two additional arguments are not persuasive. The first argument is based on a test which is so stringent it is not meaningful, since to pass the test the two input price series would have to be virtually identical in every year<sup>5</sup>. The second argument is based on LEC input price data generated from Norsworthy's Performance-Based Model. This model is sufficiently flawed that the price data it generates are not reliable.

#### Problems With Norsworthy's Performance-Based Model

12. Norsworthy has provided his own measurement of the LEC's input price growth rate for the period 1985-94, and hence his own measurement of the input price differential. There are a number of significant problems with his capital data construction procedures which render the capital input price series unreliable. In addition, Norsworthy's use of a quality-adjusted capital input price series makes his calculated input price differential non-comparable to the Bush-Uretsky result, even though on the surface they appear to be of similar magnitude.
13. There are at least six problems with the capital data (input and input price) which render the calculated input price differential unreliable.
  - (a). First, Norsworthy uses the book value of the capital stock as his measure of the capital input. Book value is an accounting concept which generally bears little relationship to the economic value of capital. Replacement value is the conceptually correct measure of the economic value of capital. I know of no productivity analyst

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<sup>5</sup> The extreme stringency of this test is explored in Appendix B.

who would use book value of capital without apologizing for the inability to construct estimates of replacement value due to the lack of data. The Christensen simplified TFP model constructs replacement value of capital based on the available US government price deflators.

(b). Second, use of **net** book value implies the use of FCC prescribed depreciation rates which are unlikely to mirror the economic depreciation rates needed to construct economically relevant net stocks of capital.

(c). Third, the use of book value of capital and FCC prescribed depreciation rates means that Norsworthy's calculated rate of return is an accounting rate of return. His accounting rate of return is unlikely to correspond to the economic rate of return which is the correct rate of return to include in the calculation of the capital input price. To determine the correct economic rate of return, Norsworthy would need to use the economic value of capital and economic depreciation rates in his calculation. The economic value of the capital stock and economic depreciation rates are used in Christensen's TFP model.

(d). Fourth, while both debt and equity sources of financing should be taken into account in the construction of the user cost of capital (as the Christensen simplified approach does), Norsworthy's treatment appears to be incorrect. Judging from his calculation of the alleged overstatement of the user cost of capital in Christensen's earlier versions of his productivity model (page 82), Norsworthy appears to be assuming that the pre-tax cost of debt is equal to the post-tax cost of equity. Debt and equity embody different risk factors due to a firm's different obligations to the



holders of these two sources of capital financing. There is no apparent reason why the costs of debt and equity should be equal<sup>6</sup>.

(e). Fifth, Norsworthy's reformulation of the equation for calculating the capital input price in order to account for the unequal taxation treatment of debt and equity costs appears to be incorrect<sup>7</sup>. Since the derivation of the tax-adjusted formula is not given, a more definitive statement is not possible. But his equation is inconsistent with previous versions of the user cost of capital services which treat tax effects explicitly, such as those found in Fuss and Waverman (1981), and Jorgenson and Yun (1991).

(f). Sixth, Norsworthy's method of quality adjustment is flawed. He adjusts the capital input price for quality changes using procedures based on his previous research (Norsworthy et al (1993))<sup>8</sup>. The econometric model which underlies this adjustment contains unwarranted parameter restrictions. While the details are fairly technical,<sup>9</sup> in essence what has happened is that Norsworthy has imposed more restrictions on the

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<sup>6</sup> Carlton and Perloff (1994, page 337) provide a textbook statement of the importance of recognizing the differing costs of debt and equity capital in the calculation of the firm's rate of return.

<sup>7</sup> The formula is given in equation (14) of Attachment 2, Appendix A of Norsworthy's Statement.

<sup>8</sup> These quality adjustment procedures do not correspond to the standard hedonic methodology. The hedonic methodology analyses the relationships between the prices (or production costs) of capital equipment and the quality characteristics of the equipment.

<sup>9</sup> It is common in cost function estimation to impose those parameter restrictions necessary to ensure that the cost function is linearly homogeneous in input prices. This will ensure that the function being estimated has the property that if all input prices increased by some percentage, total cost would increase by the same percentage. Norsworthy imposes these parameter restrictions, but also imposes additional parameter restrictions which are not needed to ensure that the estimated cost function satisfies this property.

parameters of his model than are necessary, thus biasing in unknown ways the estimates of those parameters that determine the quality adjustments.

14. The model is also specified in such a way that **all** technological progress in the supply of telecommunication services associated with reductions in labor and material costs results in an increase in the quality of capital inputs. This increased quality appears as "more" capital input in the TFP calculations. In effect, all technological progress which results in savings in labor and material costs is credited to the equipment supplying industry, and none is credited to the industry which supplies telecommunication services.
15. Due to the problem identified in the last paragraph, Norsworthy's model specification imparts an upward bias to the capital input quality adjustment, which implies an upward bias in the capital input growth rate. This upward bias has an important effect on the input price differential. Because there is an upward bias in the growth rate of the capital input quantity series, there is a corresponding downward bias in the growth rate of the capital input price series. The result is that Norsworthy's input price differential is overstated.
16. However, since the resulting downward adjustment in the rate of change of the capital input price is accompanied by a corresponding and offsetting upward adjustment in the rate of change of the capital input, Norsworthy's flawed quality adjustment procedure has no impact on his calculated X factor. Therefore Norsworthy's criticism

that Christensen does not explicitly adjust his capital data for quality change is of no relevance from a quantitative perspective.<sup>10</sup>

17. Norsworthy fails to point out that his calculated input price differential of 2.54% is not comparable to the 2.23% calculated by Bush and Uretsky. In fact the implication is left with the reader that the closeness of the two numbers is confirmation of their validity. In fact, Norsworthy's input price differential estimate contains a quality adjustment whereas Bush and Uretsky's does not; the two numbers are simply not comparable, and their apparent closeness is simply an irrelevant coincidence<sup>11</sup>.
18. These two differentials can be placed on a more comparable basis by removing the quality adjustment from Norsworthy's data. On page 34, Norsworthy states that his quality adjustment resulted in "a very small (or no) effect on the X factor". Since,

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<sup>10</sup> The fact that quality change adjustments have no effect on Norsworthy's estimate of the X factor is peculiar to his adjustment procedure. In general, quality adjustment using hedonics can increase or decrease the X factor; a zero effect is unlikely unless the economy-wide TFP and input price changes are adjusted as well - something that Norsworthy did not do.

It is very difficult to adjust the X factor properly for quality change, even given agreement on the econometric equation which provides the quality estimates. While the capital input price growth rate can be adjusted directly for quality change, proper quality adjustment of the capital input quantity growth rate is another matter. The reason why quality adjustment of the capital input growth rate is problematic is that at any point in time all surviving capital would need to be adjusted. This would require a complete historical knowledge of the characteristics of the past capital put in place which comprises the benchmark capital.

This problem carries through to ETI's comments on behalf of Ad Hoc. In all likelihood because of the difficulties in making quality adjustment to capital growth, ETI does not adjust Christensen's benchmark capital stock for quality change in their quality adjustment simulations. But this omission results in an incorrect procedure which biases upward ETI's estimated X factor. The input quantity growth rate is biased downward, but the input price growth rate does not contain an offsetting bias (as is the case with Norsworthy's calculations).

ETI's capital input growth rate is underestimated because the failure to quality-adjust the benchmark stock renders it too large, and hence too much of the observed investment over the 1984-93 period is replacement investment, rather than additions to the net capital stock. Under the perpetual inventory capital accumulation methodology, when replacement investment is too large, the net capital stock grows too slowly.

<sup>11</sup> It should be noted that Norsworthy only adjusts the LECs input prices for quality change. In order to be consistent, he should also adjust the US economy input prices for quality change.

from table 15, we can calculate that the quality adjustment increased the growth rate of the capital input by 3.27%, the growth rate of the capital input price used in the LEC input price series must have decreased by approximately 3.27%, if the X-factor is to remain virtually unchanged. Replacing the adjusted capital input price index with the unadjusted one in table 5, and assuming that capital costs are 50% of total costs, the unadjusted input price growth rate differential is 0.91%. This is the number which should be compared with Bush and Uretsky's 2.23%. Regardless, neither calculation provides a legitimate basis to conclude that there should be an ongoing non-zero input price differential.

#### 4. Depreciation Rates

19. The depreciation of capital in the Christensen model is based on economic depreciation rates as calculated using the Hulten and Wykoff (1981) methodology. The Hulten-Wykoff methodology is used in most productivity studies which calculate capital accumulation using the perpetual inventory procedure. This is because their methodology accounts for both obsolescence (which leads to retirements which are not observed) and physical decay (which leads to reduced efficiency). Hence the Hulten-Wykoff methodology estimates the economic depreciation of capital. It is certainly true that the depreciation rates calculated by Hulten and Wykoff are likely to be dated. However, the Christensen model does not use the Hulten-Wykoff depreciation rates, but rather Hulten and Wykoff's estimated relationships between economic lifetimes and

geometric depreciation rates<sup>12</sup>. The Christensen procedure is to substitute the most recent Bureau of Economic Analysis lifetimes into these relationships to obtain depreciation rates. While it is clear that economic lifetimes have changed since the 1970s (they have surely shortened for telecommunications equipment), it is not at all clear that the relationship between depreciation rates and lifetimes have changed. This is an empirical question, and I agree with Norsworthy that this question is worthy of study. It is not, however, a feasible recommendation for the current proceedings. Such a study would be a long term research project, since it would be necessary to collect and analyse a large volume of transaction prices of used telecommunications equipment.

20. Finally, I find it strange that Norsworthy criticizes the Christensen depreciation rates as being **too high** (page 49) (emphasis mine). If anything, the Bureau of Economic Analysis communications equipment lifetimes will overstate the actual lifetimes due to the probable increasing importance of obsolescence which has not as yet found its way into official government lifetime estimates<sup>13</sup>.

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<sup>12</sup> As both Norsworthy and ETI remark, the estimated relationships, involving a factor of 1.65 for communications equipment and 0.90 for telephone and telegraph structures, are based on averages of other classes of capital. It should be noted that these averages were chosen as reasonable by the two leading researchers in the area of estimating economic depreciation rates.

<sup>13</sup> ETI provides estimates of TFP growth when the depreciation rates are increased relative to those used in the Christensen model. However ETI's failure to adjust Christensen's benchmark capital stock for the assumption of increased depreciation rates means that their estimates of TFP growth (and the X factor) are biased upwards. Similar to the problem ETI encounters with its quality adjustment procedure, ETI's capital input growth rate is underestimated, and hence TFP growth is overestimated. This occurs because the failure to adjust the benchmark stock for the increased depreciation rate renders it too large. Too much of the observed investment over the 1984-93 period is replacement investment, rather than additions to the net capital stock. Under the perpetual inventory capital accumulation methodology, when replacement investment is too large, the net capital stock grows too slowly.

does) to aggregate prices and quantities. From an empirical perspective it usually makes little difference which index is used.

24. Table 1 demonstrates the close correspondence between the Fisher and Tornquist indices for the data contained in Norsworthy's model. I have used Norsworthy's data to construct aggregate output and input Fisher and Tornquist indices for the LECs' regulated services<sup>14</sup>. I have also constructed these indices for the aggregate input price<sup>15</sup>. As can be seen from table 1, the growth rates of the Fisher and Tornquist indices of aggregate output, input, and input price are virtually identical. The yearly indices are presented in table D.1 of Appendix D. The Fisher and Tornquist indices are almost identical, to three decimal places.
25. The close correspondence between the Fisher and Tornquist indices which I have found is not surprising and has been noted in the literature. Appendix D contains a detailed description of the rationale behind this close correspondence.

## 6. Conclusion

26. AT&T and Ad Hoc's central criticisms of the Christensen productivity model are unfounded. Indeed, it is AT&T's proposed alternative model that contains fundamental economic flaws.

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<sup>14</sup> Norsworthy's Fisher Index growth rate calculations appear in table 7.

<sup>15</sup> These indices correspond to the data in Norsworthy's table 5.

I declare, under penalty of perjury, that the foregoing is true and correct.

Executed on February 26, 1996

A handwritten signature in cursive script, reading "Melvyn A. Fuss", is written over a horizontal line.

Melvyn A. Fuss

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Table 1A Comparison of Fisher and Tornquist Index Growth RatesNorsworthy Data 1985-94

<u>Aggregation</u>	<u>Fisher Index</u>	<u>Tornquist Index</u>
Output Growth - All LEC Regulated Services	4.90%	4.90%
Input Growth - All LEC Regulated Services	1.89%	1.90%
Input Price Growth - All Inputs	0.46%	0.46%